Electron and ion desorption working group summary

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Introduction

The working group was created during the 13th ICFA Beam Dynamics Mini-Workshop about *Beam Induced Pressure Rise in Rings*, held in December 2003 at Brookhaven National Laboratory. This note briefly summarizes the discussion about electron and ion desorption phenomenon currently observed at different accelerator laboratories.

Summary

A starting point for discussion was the overview of available data for heavy-ion induced desorption yields measured as a function of the ion energy. The plot, which was presented during the workshop, is displayed in Fig.1. Effective molecular desorption yields, derived from machine experiments (AGS: Au^{31+}, SIS 18: U^{28+}, RHIC: Au^{79+}), are compared with dedicated "test-stand" experiments (LINAC 3: Pb^{53+}, HLI: Pb^{27+}, Zn $^{10+}$).

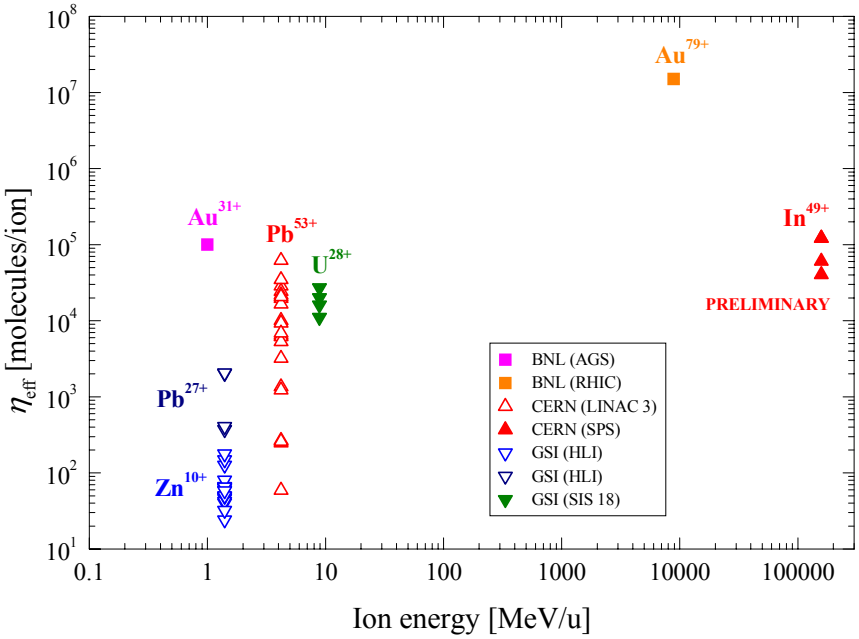

FIG. 1. Overview of heavy-ion induced desorption data, obtained at BNL, CERN, and GSI. The ion impact angles (perpendicular, mrad, μrad) of the experiments are different (see text).

The working group discussed the question of whether test-stand experiments give adequate answers to accelerator questions. We concluded that one has to distinguish between the low energy case (MeV/u) and the high energy case (GeV/u). For low energy

machines, like AGS Booster, SIS18, and LEIR, charge exchange processes (capture & loss) lead to beam-losses onto the vacuum chamber with well-defined impact angles in the mrad range. Therefore, dedicated experiments with extracted beam (e.g. at LINAC 3 or HLI) should give the right values for effective molecular desorption yields. The situation is different (no charge exchanges) for high energy machines, like RHIC and LHC, where losses are due to non-linear dynamics and nuclear scattering, and result in very small impact angles in the μrad range or even less. Therefore, corresponding experiments are much more complicated. It was emphasized that a well defined scraper experiment, like the LHC-type collimator material test, recently done with In^{49+} ions at the SPS, would be also desirable in a warm section of RHIC in order to verify the estimated yield of 1.5×10^7 molecules per Au^{79+} ion.

The working group also addressed the question of how possible future machine experiments could evolve. The following proposals were made and discussed:

- BNL is currently installing a test-stand at the Tandem machine in order to measure and verify the low energy desorption yield (10^5 molecules/Au^{31+} ion), previously obtained at the AGS Booster. Desorption experiments with NEG coatings (comparison between activated and saturated getter) are planned. One should also think about measurements at higher energies, for example using a slow extraction line from the Booster which could deliver heavy ions with an energy up to 1 GeV/u and intensities between 10^6 and 10^9 ions/s.
- At GSI, further experiments are under consideration at HLI, UNILAC, and SIS where U^{28+} ions up to about 1 GeV/u can be used for desorption yield studies. Measurements of cold surfaces are considered to be very important for the GSI future project, but also for RHIC and LHC.
- At the Svedberg Laboratory (Uppsala), desorption tests with Ne, Ar, and Xe ions are possible at energies up to 46 MeV/u. This option is interesting because of the intermediate energy range which is not covered by other laboratories.
- The working group discussed the possibility of a machine experiment in a warm section of RHIC and elaborated a possible experimental set-up to test different samples either under perpendicular or grazing impact. The advantage of such a test would be to get another high energy data point under well defined conditions (ion energy, ion intensity, impact angle). A potential drawback is that an extreme grazing incidence angle (some μrad) would require a complicated set-up with a precise alignment and measurement of the number of impacting ions on the target in order to calculate the effective desorption yield. The working group recommended the installation of a simple experiment in a warm section of RHIC and to study the feasibility of a "single-pass experiment" at injection energy. A possible experimental set-up, which would allow dedicated desorption studies on different samples either under perpendicular impact or under grazing angle (some mrad), is sketched in Fig. 2.

The working group collected all pressure rise observations reported so far from different accelerator laboratories world-wide, and identified experimental set-ups that are either currently running, starting up, or are possible in the future. An overview is shown in Table 1.

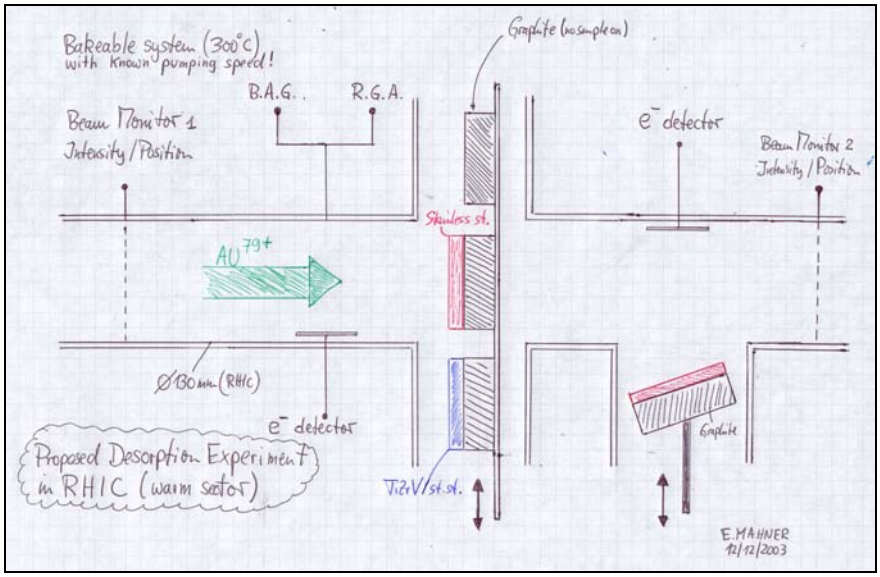

FIG. 2. Proposed RHIC single-pass experiment to measure heavy-ion induced molecular desorption of Au^{79+} impacting on different targets.

Accelerators				Experimental setups			
	E [MeV/u]	Ion	Target		E [MeV/u]	Ion	Target
BNL Booster	1-100	Au31+	valve, chamber wall	BNL Tandem	1	Au31+	chamber wall
BNL RHIC	8900	Au79+	valve, chamber wall, samples				
CERN LEAR	4.2	Pb54+	chamber wall	CERN LINAC3	4.2	Pb27+/53+	chamber wall
				CERN SPS	158000	In49+	collimator
GSI SIS	10 to 100	p to U28+	chamber wall	GSI HLI	1.4	C,Pb,Cr, Zn	samples
	10	U28+	scraper, chamber wall	GSI UNILAC	2 to 11	p to U	to define
				GSI SIS18	10 to 1000	p to U	to define
LBNL					0.025	K+	samples
The Svedberg Lab.				Uppsala	<46	Ne,Ar,Xe	to define
observed	running	starting	possible				

TABLE 1. Overview of pressure rise observations in different accelerators and various experiments, classified as: running, starting, and possible in the future.

Some other important topics were raised but could only be discussed briefly. Therefore we simply list them as "open questions and what has to be studied in the future":

- Theoretical aspects of ion-beam induced desorption
  - Applied surface physics: could/would they help?
  - Is the desorption phenomenon a surface or a bulk effect?
  - Measurements should be performed with well defined (characterized) samples.
  - The objective is to understand the physics.

- What has to be considered and carried out in future experiments
  - More NEG desorption experiments with heavy ions.
  - Cold surfaces: mounted samples on a cold head (first step).
  - Electron detection: how do secondary electrons contribute?

- Instrumentation for experiments (seems to be trivial, but it is not)
  - One has to know: pumping speed, number of lost ions, impact angle, chamber volume….
  - Use calibrated instruments: ion gauge, residual gas analyser.
  - The objective is to benchmark experiments for reliable comparison.

Conclusion

The working group concluded that it is very important to gain a better understanding of the theoretical aspects of the heavy-ion induced desorption phenomenon, to close the gap of missing data between the MeV/u and GeV/u energy range, and to perform reliable and comparable measurements. No concrete proposals were made how to proceed in detail. The working group proposed and recommended a dedicated desorption experiment with Au^{79+} ions in a warm section of RHIC.